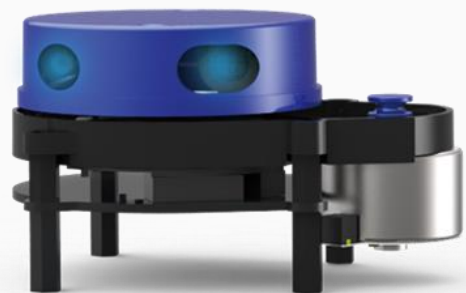


X4 DEVELOPMENT MANUAL



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1 WORKING MECHANISM

The YDLIDAR X4(hereinafter referred to as X4) system has 3 working modes: idle mode, scan mode and stop mode.

- **Idle mode:** When X4 is powered on, the default mode is idle mode. In idle mode, the X4's ranging unit does not work and the laser is not light.
- **Scan mode:** When X4 is in scanning mode, the ranging unit turns on the laser. When the X4 starts to work, it continuously samples the external environment and outputs it in real time after background processing.
- **Stop mode:** When X4 runs with an error, such as turning on the scanner, the laser is off, the motor does not rotate, etc.X4 will automatically turn off the distance measuring unit and feedback the error code.

1.1 System Workflow

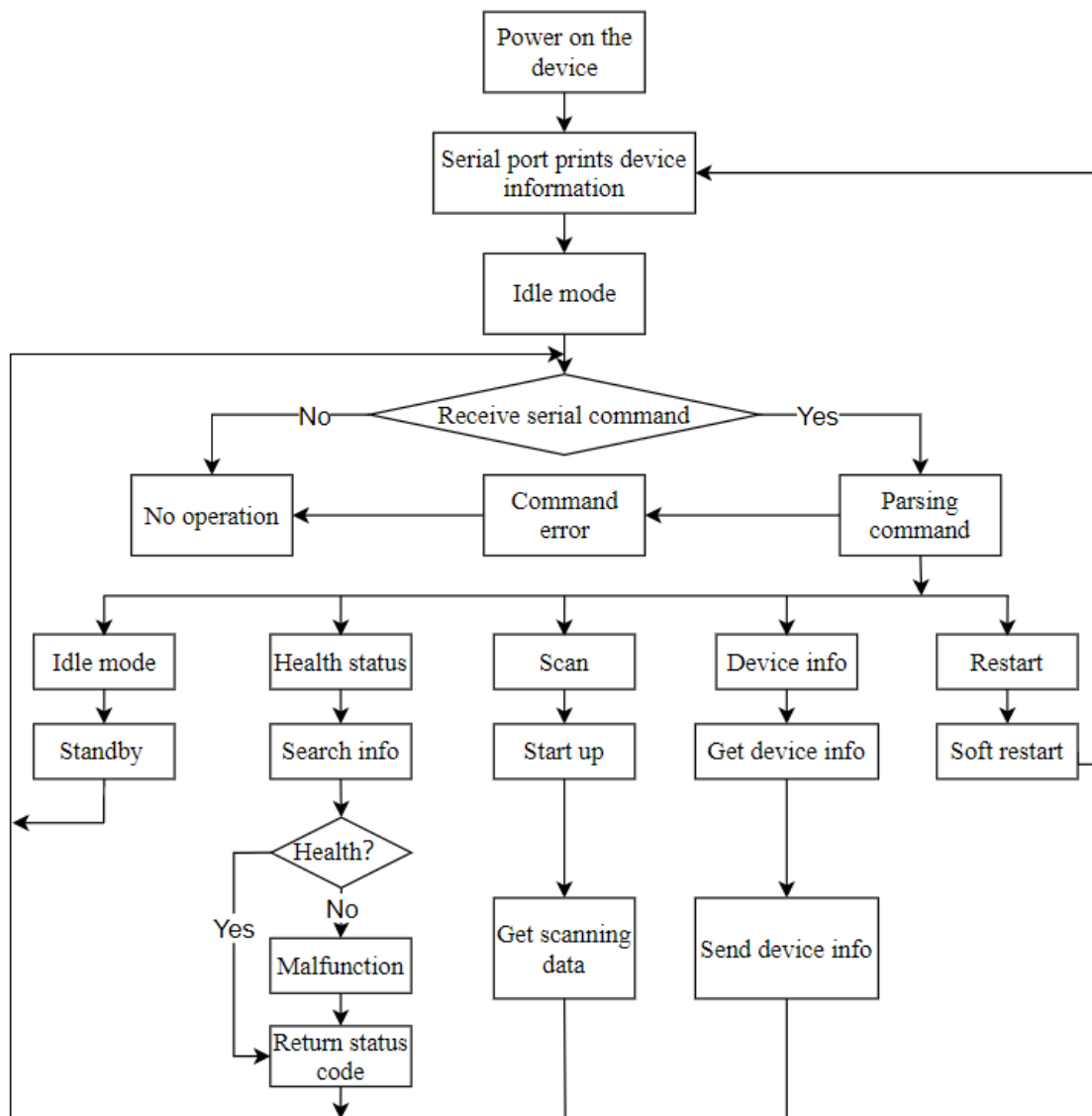


FIG 1 YDLIDAR X4 WORKFLOW

2 SYSTEM COMMUNICATION

2.1 Communication Mechanism

X4 communicates commands and data with external devices through the serial port. When an external device sends a system command to X4, X4 resolves the system command and returns a corresponding reply message. According to the command content, X4 switches the corresponding working status. According to the content of the message, the external system can parse the message and obtain the response data.

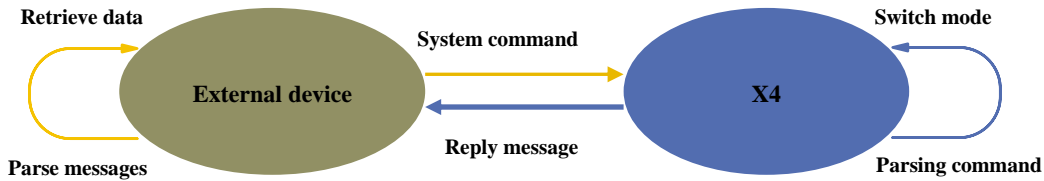


FIG 2 YDLIDAR X4 SYSTEM COMMUNICATION

2.2 System Command

The external system can set the corresponding working status of X4 and send corresponding data by sending related system commands. The X4 system command is unified to 2 bytes, where the start byte is 0xA5 and the second byte is the command content. The system commands issued by X4 are as follows:

CHART 1 YDLIDAR X4 SYSTEM COMMAND

System command	Description	Mode switching	Answer mode	
0xA5 (Start)	0x60	Start scanning and export point cloud data	Scan mode	Sustained response
	0x65	Stop and stop scanning	Stop mode	No answer
	0x90	Get device information (model, firmware, hardware version)	No	Single response
	0x91	Get device health status	No	Single response
	0x80	Soft restart	/	No response

2.3 System Messages

The system message is a response message that the system feeds back based on the received system command. According to different system commands, the reply mode and response content of the system message are also different. There are three kinds of response modes: no response, single response, continuous response.

No response means that the system does not return any messages. A single reply indicates that the system's message length is limited, and the response ends once. Sustained response means that

the system's message length is infinite and needs to send data continuously, such as when entering the scan mode.

The one-time response and continuous response messages use the same data protocol. The contents of the protocol are: start sign, response length, response mode, type code and response content, and are output through the serial port hexadecimal system.

CHART 2 YDLIDAR X4 SYSTEM MESSAGE DATA PROTOCOL

Start sign	Response length	Response mode	Type code	Content
16bits	30bits	2bits	8bits	/

Bite offset:

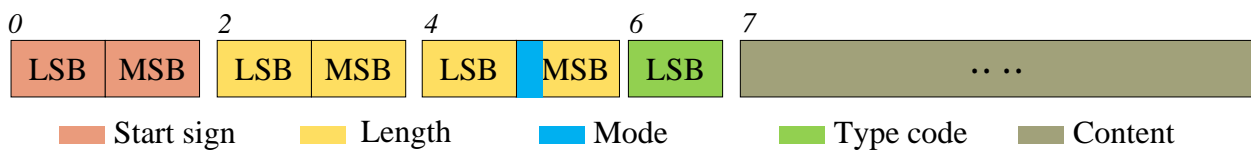


FIG 3 YDLIDAR X4 SYSTEM MESSAGE DATA PROTOCOL

- **Start sign:** X4's message sign is unified as 0xA55A.
- **Response length:** When the answer mode is continuous, the length should be infinite, so this value is invalid.
- **Response mode:** This bit has only 2 bits, which means this time it is a single response or continuous response. Its value and corresponding mode are as follows:

CHART 3 YDLIDAR X4 RESPONSE VALUE

Mode	0x0	0x1	0x2	0x3
Response mode	Single response	Continuous response	Undefined	

- **Type code:** Different system commands correspond to different types codes.
- **Content:** Different system commands, feedback different data content, and their data protocols are also different.

Note 1: The X4 data communication adopts the little-endian mode and the low-order mode.

Note 2: In the reply message, the lower 6 bits of the 6th byte belong to the response length and the upper 2 bits belong to the response mode.

3 DATA PROTOCOL

Different system commands have different message contents. In message with different types of codes, the data protocol of the response content is also not the same. Therefore, users need to parse the data in the response content according to the corresponding data protocol, such as point cloud data, device information, etc.

3.1 Scan Command [A5 60]

When an external device sends a scan command to X4, X4 goes into scan mode and feeds back point cloud data. The reply message is:

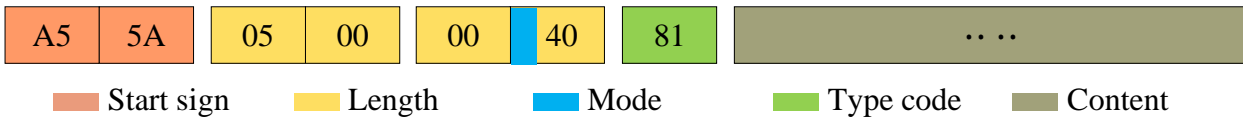


FIG 4 YDLIDAR X4 SCAN COMMAND

The 6th byte high 2 is 01, so the response mode takes 0x1, which is a continuous response, ignoring the response length, and the type code is 0x81.

The response content is the point cloud data scanned by the system. According to the following data structure, the data is sent to the external device in hexadecimal to the serial port.

Byte offset:

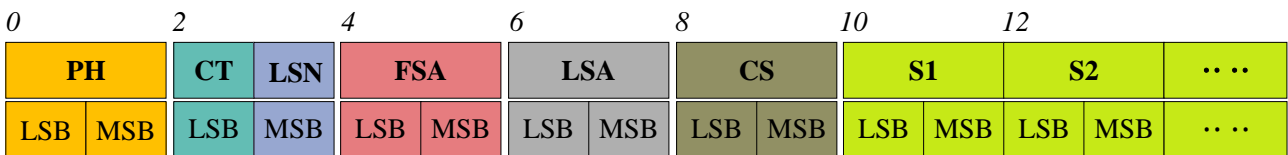


FIG 5 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE

CHART 4 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE DESCRIPTION

Content	Name	Description
PH(2B)	Packet header	2B in length, fixed at 0x55AA, low in front, high in back
CT(1B)	Package type	Indicates the type of the current data packet, CT[bit(0)]=1 indicates the start of a round of data, CT[bit(0)]=0 indicates the point cloud data packet, CT[bit(7:1)] is Reserved bits
LSN(1B)	Sample quantity	Indicates the number of sampling points contained in the current packet. There is only one initial point of data in the zero packet. The value is 1.
FSA(2B)	Start angle	The angle data corresponding to the first sample point in the sampled data
LSA(2B)	End angle	The angle data corresponding to the last sample point in the sampled data
CS(2B)	Check code	The check code of the current data packet uses a two-byte exclusive OR to check the current data packet.
Si(2B)	Sample data	The system test sampling data is the distance data of the sampling point.

➤ **Start bit & scan frequency analysis**

When $CT \& 0x01 = 0$ is detected, it indicates that the packet data is point cloud packet;

When $CT \& 0x01 = 1$ is detected, it indicates that the packet data is the start packet, representing the beginning of a cycle of data. In this packet, $LSN=1$, that is, the number of S_i is 1; for the specific value analysis of the distance and angle, please refer to the following; at the same time, in the start data packet, $CT[bit(7:1)]$ scan frequency information, $F = CT[bit(7:1)]/10$ (when $CT[bit(7:1)] = 1$).

Note: When CT[bit0]=0, CT[bit(7:1)] is a reserved bit, and future versions will be used for other purposes. Therefore, in the process of parsing CT, only bit(0) is required to determine the starting frame.

➤ **Distance analysis:**

Distance solution formula: $Distance_i = \frac{Si}{4}$

Among them, Si is the sampled data. Set the sampling data as E5 6F. Since the system is in small-terminal mode, the sampling point $D = 0x6FE5$ is substituted into the Distance solution formula to obtain the $Distance=7161.25mm$.

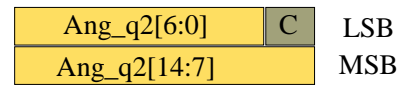
➤ **Angle analysis:**

Angle data is stored in FSA and LSA, and each Angle data has the following data structure, where C is the check bit and the value is fixed to 1. There are two levels of angle analysis: first-level analysis and second-level analysis. The first-level analysis obtains the initial value of the angle, and the second-level analysis corrects the initial value of the angle. The specific process is as follows:

First-level analysis:

Starting angle solution formula: $Angle_{FSA} = \frac{Rshiftbit(FSA,1)}{64}$

End angle solution formula: $Angle_{LSA} = \frac{Rshiftbit(LSA,1)}{64}$



Intermediate angle solution formula:

FIG 6 ANGLE DATA STRUCTURE

$$Angle_i = \frac{diff(Angle)}{LSN-1} * (i - 1) + Angle_{FSA} \quad (i = 2, 3, \dots, LSN - 1)$$

$Rshiftbit(data, 1)$ means shifting the data to the right by one bit. $diff(Angle)$ means the clockwise angle difference from the starting angle (uncorrected value) to the ending angle (uncorrected value), and LSN represents the number of packet samples in this frame.

Second-level analysis:

Angle correction formula: $Angle_i = Angle_i + AngCorrect_i \quad (i = 1, 2, \dots, LSN)$

Among them, AngCorrect is the angle correction value, and its calculation formula is as follows, \tan^{-1} is the inverse trigonometric function, and the angle value is returned:

IF $Distance_i == 0$ $AngCorrect_i = 0$

ELSE $AngCorrect_i = \tan^{-1}\left(21.8 * \frac{155.3 - Distance_i}{155.3 * Distance_i}\right)$

Assuming that the 4th to 8th bytes in the data packet are 28 E5 6F BD 79, so $LSN = 0x28 = 40(dec)$, $FSA = 0x6FE5$, $LSA = 0x79BD$, and the first-level solution formula is brought into:

$$Angle_{FSA} = 223.78^\circ, Angle_{LSA} = 243.47^\circ, diff(Angle) = 19.69^\circ$$

$$Angle_i = \frac{19.69^\circ}{39} * (i - 1) + 223.78^\circ \quad (i = 2, 3, \dots, 39)$$

Assuming that in this frame of data, $Distance_1 = 1000$, $Distance_{LSN} = 8000$, and the second-level calculation formula is brought into it, and get:

$$AngCorrect_1 = -6.7622^\circ, AngCorrect_{LSN} = -7.8374^\circ, \text{ so:}$$

$$Angle_{FSA} = Angle_1 + AngCorrect_1 = 217.0178^\circ$$

$$Angle_{LSA} = Angle_{LSA} + AngCorrect_{LSA} = 235.6326^\circ$$

In the same way, $Angle_i$ ($i = 2, 3, \dots, LSN - 1$) can be obtained in turn.

➤ **Check code parsing**

The check code uses a two-byte exclusive OR to verify the current data packet. The check code itself does not participate in XOR operations, and the XOR order is not strictly in byte order. The XOR sequence is as shown in the figure. Therefore, the check code solution formula is:

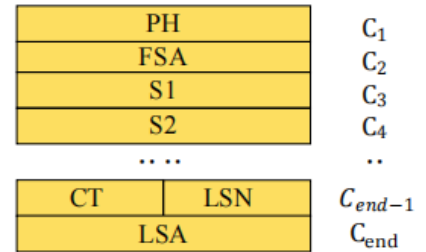


FIG 7 CS XOR SEQUENCE

$$CS = XOR_1^{end}(C_i) \quad i = 1, 2, \dots, \text{end}$$

XOR_1^{end} indicates the XOR of the element from subscript 1 to end. However, XOR satisfies the exchange law, and the actual solution may not need to follow the XOR sequence.

3.2 Stop Command [A5 65]

When the system is in the scanning state, X4 always sends point cloud data to the outside. If the user need to turn off scanning at this time, it can send this command to stop the system from scanning. After the stop command is sent, the system will be in the standby state. At this time, the ranging unit of the device is in the low power mode, and the laser is not lit.

The command is unresponsive, so the system will not respond to any messages after receiving the command.

3.3 Device Information [A5 90]

When an external device sends a Get Device Information command to (A5 90), X4 will feedback the device's model, firmware version, and hardware version, and the device's factory serial number. The reply message is:

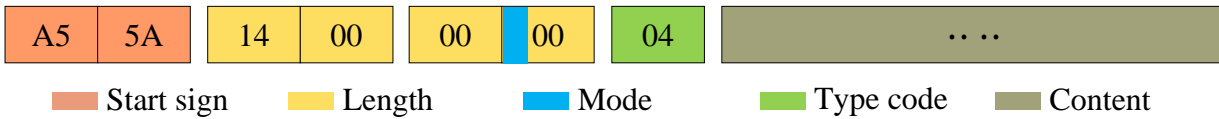


FIG 8 YDLIDAR X4 DEVICE INFORMATION

According to the protocol resolution: response length = 0x00000014, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 20. The response is a single response and the type code is 04. This type of response content satisfies the following data structure:

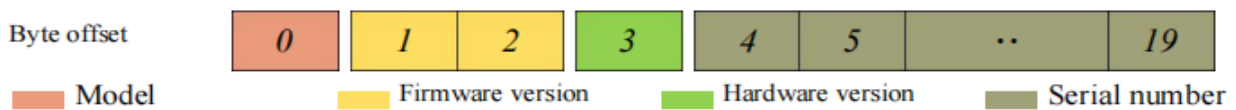


FIG 9 YDLIDAR X4DEVICE INFORMATION RESPONSE CONTENT DATA STRUCTURE

- **Model number:** One-byte device model, such as the X4 is 06.
- **Firmware Version:** 2 bytes. The low byte is the major version number, and the high byte is the minor version number.
- **Hardware version:** 1 byte for hardware version.
- **Serial number:** 16 bytes, the only factory serial number.

3.4 Health Status [A5 91]

When an external device sends a health status command (A5 91) to X4, X4 will give back the status code of the device. The reply message is:

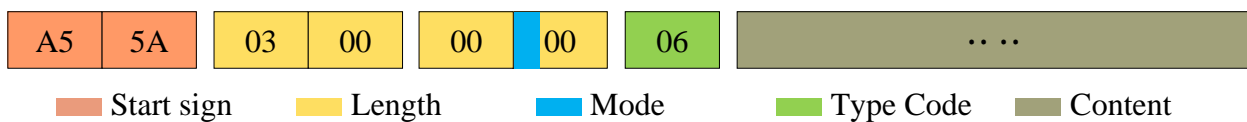


FIG 10 SCHEMATIC DIAGRAM OF YDLIDAR X4 RADAR EQUIPMENT HEALTH STATUS MESSAGE

According to the protocol resolution: response length = 0x00000003, answer mode = 0x0, type code = 0x06.

That is, the number of response content bytes is 3. This response is a single response and the type code is 06. The type of reply content satisfies the following data structure:

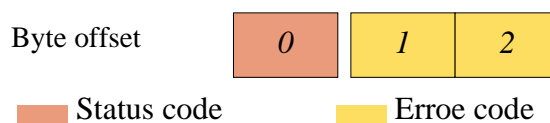


FIG 11 SCHEMATIC DIAGRAM OF DATA STRUCTURE OF HEALTH STATUS RESPONSE CONTENT OF YDLIDAR X4 EQUIPMENT

- **Status code:** 1 byte, 0x0 means the device is running normally, 0x1 means the device is running warning, 0x2 means the device is running incorrectly.
- **Error code:** 2 bytes, when there is a warning or error state, the specific error code will be recorded in the field 0x00 means that the device runs without any error.

3.5 Restart Command [A5 80]

When an external device sends a Get Device command (A5 80) to X4, X4 enters a soft reboot and the system restarts. This command does not answer.

4 POWER CONSUMPTION CONTROL

The external interface of X4 provides motor related control interfaces (M_EN, M_SCTP) and power consumption control interfaces (DEV_EN). The user can set the three control signals to control the power consumption of the device.

4.1 Standby Control

In order to facilitate the user to use quickly, the default value of the X4 control signal (please refer to the data sheet) does not achieve the lowest power consumption. Therefore, when the user needs to debug the standby state with the lowest power consumption, it is necessary to further adjust the M_EN and DEV_EN as follows: M_EN = 0V, DEV_EN = 0V.

In this way, the enabling of the motor and the ranging enable are turned off, and the entire system is in a standby state with the lowest power consumption.

4.2 Speed Control

At the same time, users can change the scanning frequency to meet their needs according to actual needs. Adjust the motor speed by changing the input voltage of the M_SCTP pin or changing the duty cycle of the input PWM signal (for specific control methods, please refer to the data manual).

5 REVISE

Date	Version	Content
2017-12-01	1.0	Compose a first draft
2017-12-26	1.1	Optimize the layout and revise the details of the scan command content
2017-12-29	1.2	Revise the distance analysis and angle analysis content under data protocol
2018-01-15	1.3	In the data protocol, revise the distance analysis and angle analysis content, add angle correction value
2018-02-05	1.4	The restart command is revised to A5 80, and compatible with A5 40
2018-08-06	1.5	Modification of professional terms: LL---LSB, HH---MSB
2019-03-21	1.6	Change doc number: 01.13.000001